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Enhanced Defense Logistics Agency Distribution System (EDDS) Freight Terminal Simulation Analysis

OPERATIONS RESEARCH AND ECONOMIC ANALYSIS OFFICE

DEPARTMENT OF DEFENSE

DEFENSE LOGISTICS AGENCY

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Capt David E. Bertrand, USAF

Sara Poetzsch

DEPARTMENT OF DEFENSE

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CAMERON STATION,

ALEXANDRIA, VIRGINIA 22304-6100

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DEFENSE LOGISTICS AGENCY
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CAMERON STATION
ALEXANDRIA, VIRGINIA 22304-6100

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FOREWORD

This report presents the results of simulation analyses of proposed mechanization design of the freight terminals at each of the six Defense Logistics Agency (DLA) depots. The mechanization project is part of the Enhanced DLA Distribution System (EDDS), with designs developed by the DLA Depot Operations Support Office (DLA-DOSO). The purpose of the simulation analyses is to identify any problems or possible improvements and recommended changes.

The analyses indicated that the efficiency of sort workers could be improved at all depots by adding another queue area for arriving pieces and empty pallets. Also, additional workstations were required at several depots for data collection, Medical Air Line of Communication (MEDALOC) processing, and palletization. Defense Depot Columbus, Ohio required additional stretch wrap capability, while Defense Depot Memphis, Tennessee needed an entirely new sorter design to improve efficiency. Additionally, we found that sortlines and pallet conveyor lines could be shortened at four depots, reducing total costs by almost $500,000.

Christine L. Gallo
CHRISTINE GALLO
Deputy Assistant Director
Office of Policy and Plans

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EXECUTIVE SUMMARY

The freight terminal at each of the six Defense Logistics Agency (DLA) depots is being mechanized as part of the Enhanced DLA Distribution System (EDDS). The DLA Depot Operations Support Office (DLA-DOSO) has developed designs for this mechanization. The DLA Operations Research and Economic Analysis Management Support Office (DLA-DORO) performed a computer simulation of each mechanization design to identify problems, and to recommend changes.

Simulation results showed that, at all depots, workers at the sorter spend too much time waiting for cartons and an empty pallet to travel to their station so they can begin building the next pallet. This reduces worker efficiency and limits the maximum workload the sorter can handle. Addition of a second waiting area for both cartons and empty pallets was recommended, so that while a worker is building a pallet the materials needed for the next pallet are already traveling to the station. Simulation showed this change eliminated the idle time between pallet builds - the worker remains busy as long as there are enough pieces in a sort line to fill a pallet.

Additional results indicated a need for changes that were specific to each depot. Additional stations for data collection of vendor pieces were required at Defense Depot Columbus, Ohio (DDCO); Defense Depot Mechanicsburg, Pennsylvania (DDMP); Defense Depot Memphis, Tennessee (DDMT); and Defense Depot Richmond, Virginia (DDRV). At DDMP and Defense Depot Tracy, California (DDTC), additional stations were also required to process Medical Air Line of Communications (MEDALOC) pieces. More palletization stations at the sorter were needed at DDMP, DDRV, and DDTC. Additional stretch wrap capability was needed at DDCO, and the stretch wrap machine at DDTC required relocation to allow more queue space.

The sorter at DDMT needed to be redesigned. As originally designed, each of the eight sort workers had certain lines assigned solely to his or her station, so that, as workload to each customer varied day-to-day, some workers may be overworked at the same time others are idle. Simulation results clearly showed uneven utilization of the workers, and the sorter became overloaded when the lines leading to the overworked stations became full. The simulation further showed that a more flexible sorter design, allowing multiple workers to draw from the same lines, would alleviate the problem. Evaluation of three alternative new designs showed the most flexible to be the preferred design. Also at DDMT, evaluation of an optional package delivery system showed that it reduced the workload on the sorter and, therefore, increased system capacity.

In addition to these changes to improve operations, other changes were recommended to save costs. At several depots, some sorter lines were underutilized, and no lines filled to capacity. It was therefore recommended that sorter lines at DDCO, DDMT, DDOU, and DDTC be shortened or some eliminated. Also, pallet conveyor lines at DDTC, used to hold pallets before offloading, were found to be longer than necessary. Shortening these pallet lines, and sorter lines at the four depots indicated, would save almost $500,000 total. Additionally, eliminating the idle time of workers waiting for pieces and empty pallets increases their efficiency; if this had to be achieved through increased manpower, the potential cost would be about $80,000/year across all depots.

I. INTRODUCTION

A. Background. Freight terminal operations at each Defense Logistic Agency (DLA) Depot are being mechanized as part of the Enhanced DLA Distribution System (EDDS). EDDS will change the flow of material between vendors and depots, and between depots and customers, as shown in Figure 1. The depots, along with five contractor-operated commercial sites, will act as hubs in a hub-and-spoke system. All vendors in a depot's or commercial site's area will ship to that depot or site, where it will be consolidated and shipped to the appropriate storage depot. Material stored at a depot will be shipped directly to customers in its local area, or consolidated and shipped to the appropriate depot or commercial site outside its area for distribution. Each depot/commercial site will also receive transshipment material, taken from storage at another depot destined for a customer in this site's local area. While saving transportation costs, this concept puts additional workload on the freight terminal, making mechanization necessary. The DLA Operations Research and Economic Analysis Management Support Office (DLA-DORO) performed a computer simulation of the proposed mechanization designs at each depot to identify any problem areas, and to propose recommendations.

Diagrams of the freight terminal design for each depot are included in Appendix A. Material flowing through the system falls into three categories: depot stock material, retrieved from storage at the depot being modeled; transshipment material, retrieved from storage at another depot and sent to this depot for distribution to local customers; and vendor material, received from suppliers (contractors) in the local area either for storage at this depot or shipment to another depot for storage there. The flow of material and processes performed are generally similar in all the depots; this flow is graphically represented in Figure 2. Transshipment and vendor material entering on pallets, but containing pieces for multiple destinations, are first depalletized, and then join small parcel vendor material on a package conveyor. All vendor items are then diverted to data collection where they are processed. If the depot has a Medical Air Line of Communication (MEDALOC) mission, this material is further diverted to a MEDALOC workstation for processing. Vendor pieces then rejoin the transshipment material which are then joined by pieces from depot stock. Each piece is scanned for its destination, which determines its sorter line assignment. If a scanner error or invalid assignment is found, the piece is sent to an error processing station. If the line is valid, but the assigned sort line is full, the piece "loops" around the sorter, is joined by pieces from error processing, and merges with new pieces entering the sorter. If the piece is assigned a valid sort line that is not full, it enters that sort line to wait for palletization.

Sort workers draw pieces from the sort line to palletization stations, where they load the pieces onto pallets or into triwalls. After being built, the pallets are diverted for stretch wrapping, rejoin the triwalls, and are then joined by pallets from depot stock, transshipment, and vendors; these did not require depalletization because all pieces on the pallet are for the same destination. Pallets and triwalls then move to a verification workstation, where they are scanned and weighed, and finally move to the offload conveyor assigned to its destination to await loading onto a truck.

Figure 1
ENHANCED DLA DISTRIBUTION SYSTEM (EDDS)

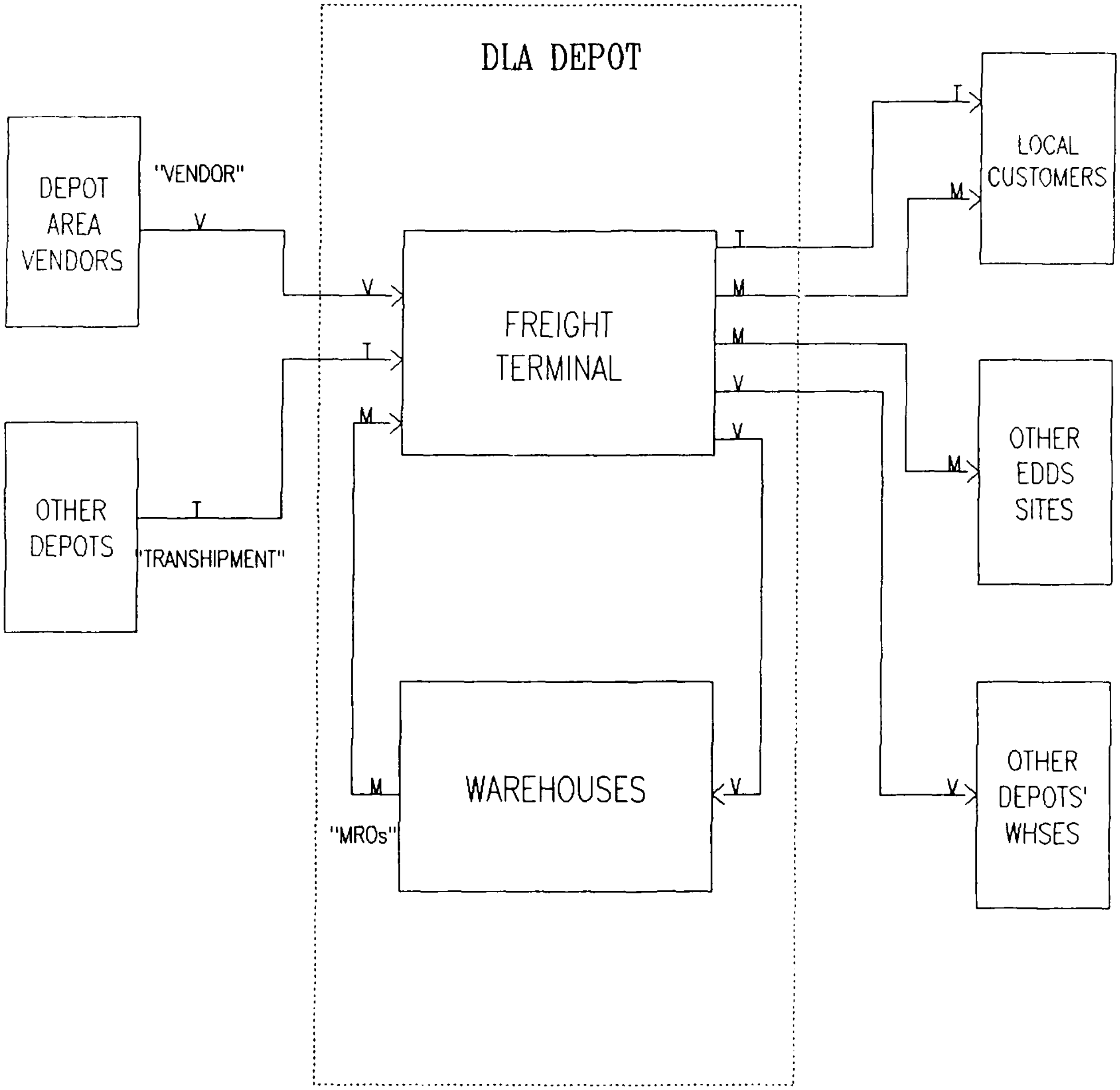
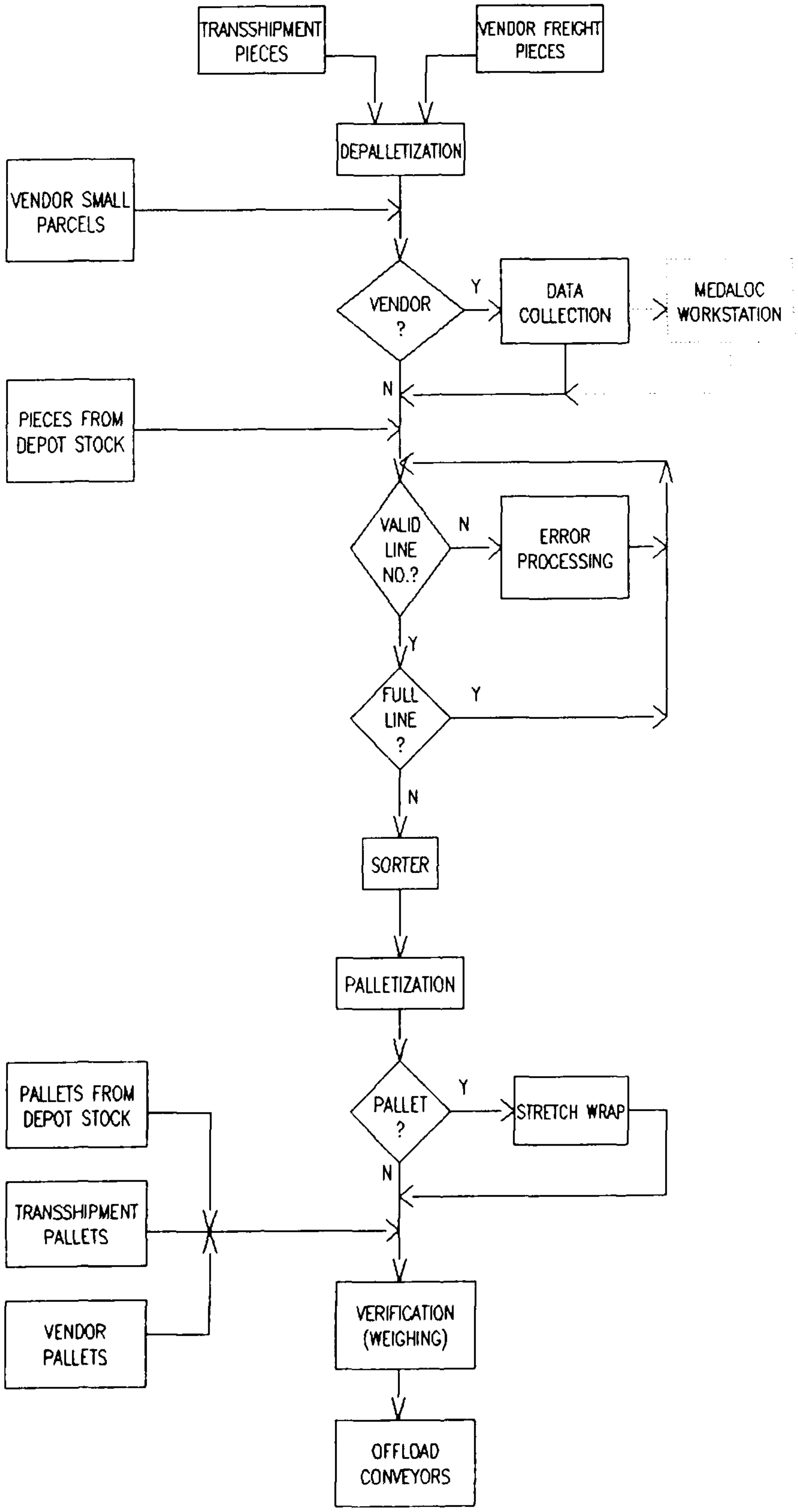


Figure 2
Freight Terminal Functional Flow



Unique to the Defense Depot Memphis, Tennessee (DDMT), design is a package delivery system (see Appendix A, p. A-4). This additional package conveyor, which is a contract option, would be used by pieces with destinations in the Memphis EDDS area, but without a specific sort line assigned to that destination. These pieces would flow off the sorter to workstations based on the destination state to be prepared for LTL shipment to the customer.

B. Problem Statement. Proposed system designs for mechanization of the DLA depot freight terminals have not been tested to ensure they can handle the expected workload.

C. Objectives. Primary objective: Test each depot's design against expected workload, and identify necessary changes. Sub-objectives:

1. Develop data on expected workload at each depot.

2. Create a simulation model of each depot's terminal design.

3. Identify any deficiencies or possible improvements in the design.

4. Recommend changes where appropriate.

D. Scope. The model will include processes internal to the freight terminal only. Processes which bring the pieces and pallets to the freight terminal, be they inside or outside the depot, will not be modeled. Processes taking the finished pallets out of the terminal will likewise not be modeled.

II. CONCLUSIONS

A. General (All Depots). Sort workers spend too much time waiting for pieces and/or empty pallets to reach the station before they can begin to build the pallet.

B. Defense Depot Columbus, Ohio (DDCO)

1. Four data collectors are not enough to process expected volume of vendor pieces.

2. Several sort lines are underutilized.

3. Semi-automatic stretch wrap machine is overworked.

4. No sort line fills to more than 19 pieces.

C. Defense Depot Mechanicsburg, Pennsylvania (DDMP)

1. Six data collectors are insufficient for expected volume of vendor material.

2. Two workers are insufficient for expected volume of MEDALOC material.

3. Six sort workers can barely keep up with expected volume; they are overwhelmed by a 10 percent increase.

D. <u>Defense Depot Memphis, Tennessee (DDMT)</u>

1. Four data collectors are insufficient for expected volume of vendor pieces.

2. Sorter design is too inflexible, since each worker has a group of lines that only he or she can work, often one or two stations are overworked while the rest are idle.

3. Package delivery system increases capacity by taking some workload off the sorter.

4. Follow-on analysis of new sorter designs showed the most flexible design with a conveyor completely around the perimeter of the sorter was superior to designs with a "U" shaped conveyor or separate conveyors on each side of the sorter.

5. No sort line fills to more than 29 pieces.

E. <u>Defense Depot Ogden, Utah (DDOU)</u>

1. System works both under normal volume and a 10 percent increase.

2. Some sort lines are underutilized.

3. No sort line fills to more than 21 pieces.

F. <u>Defense Depot Richmond, Virginia (DDRV)</u>

1. Four data collectors are near capacity at normal volume and cannot handle a 10 percent increase.

2. Six sort workers cannot handle a 10 percent increase in expected volume.

G. <u>Defense Depot Tracy, California (DDTC)</u>

1. One worker is not sufficient for expected number of MEDALOC pieces.

2. Four sort workers cannot handle a 10 percent increase in expected volume.

3. Queue space at stretch wrap machine is insufficient.

4. Several lines on sorter are underutilized.

5. No sort line fills to more than 19 pieces.

6. Offload pallet conveyors are longer than required for expected volume.

III. RECOMMENDATIONS

A. General (All Depots). Add another queue space at each sorter workstation so that two pallet loads of cartons can wait simultaneously. Similarly, provide space for two empty pallets at each station. In this way, when finished loading a pallet the worker can start immediately on the next, and while that pallet is loaded the next group of pieces and empty pallet can be travelling to the station.

B. DDCO

1. Replace semi-automatic stretch wrap machine with automatic or add another semi-automatic.

2. Add one data collection station, for total of five.

3. Consider reducing number of sort lines or shortening existing lines.

C. DDMP

1. Add two data collection stations, for total of eight.

2. Increase number of MEDALOC workstations to four.

3. Add two palletization stations at sorter, for total of ten.

D. DDMT

1. Add two data collection stations, for total of six.

2. Redesign sorter to allow the same line to be accessed by multiple workers to even out utilization and improve efficiency.

3. Include package delivery system in design.

4. Consider shortening sort lines.

5. Of the three sorter designs evaluated in the follow-on analysis, use the design with a feedline conveyor completely around sorter that allows for greatest flexibility.

E. <u>DDOU</u>

1. Consider reducing number of sort lines or shortening existing lines.

F. <u>DDRV</u>

1. Add one data collection station, for total of five.

2. Add one palletization station at sorter, for total of seven.

G. <u>DDTC</u>

1. Add one MEDALOC workstation, for total of two.

2. Add two palletization stations at sorter, for total of six.

3. Move stretch wrap machine to provide more queue space.

4. Consider reducing number of sort lines or shortening existing lines.

5. Consider shortening offload pallet conveyors.

IV. <u>BENEFITS</u>. Implementing the changes recommended in section III should ensure each design has the proper resources and configuration to handle the volume of material expected and at least a 10 percent increase. Making these changes now, in the design phase, can be done for considerably lower cost than trying to increase capacity after the system is installed. Increased personnel costs caused by recommended additional stations can be minimized since, in many cases, these stations need only be manned during peak periods. Cost reduction can be achieved by eliminating or shortening sort lines where recommended. Table 1 shows the anticipated cost savings from shortening sort lines and pallet conveyors. The additional queue space at each sort worker should save costs by increasing the productivity of the workers. Based on the simulation, a conservative estimate of the increase in sort worker capacity is 10 percent. If the increased capacity had to be attained through increased manpower, the potential cost would be approximately $80,000 per year combined for all six depots (39 total sort workers x 10% x $20,000/year based on GS-5 salary and fringe benefits).

V. <u>IMPLEMENTATION</u>. The recommendations in section III have been incorporated into the freight terminal designs as part of the contracting package sent to each bidder, to be made part of the final contract.

Table 1

ANTICIPATED COST SAVINGS

DDCO	Reduced 60 sort lines from 35 ft. to 30 ft.	$75,900
DDMT	Reduced 60 sort lines from 35 ft. to 30 ft.	75,900
DDOU	Reduced 48 sort lines from 35 ft. to 30 ft.	60,720
DDTC	Reduced 60 sort lines from 35 ft. to 30 ft.	75,900
	Reduced 13 pallet conveyor lines from 88 ft. to 60 ft.	207,480
		$495,900

VI. METHODOLOGY

A. Assumptions and Limitations

1. Eight Hour Workday. Assumed all depots would use an 8-hour workday and 5-day workweek. That is, the daily number of pieces/pallets would have to be processed by the freight terminal within an 8-hour period.

2. Drop Patterns. Since the analysis used historical patterns to determine daily amounts dropped at the depots, we assumed the implementation of EDDS would not change these patterns.

3. Steady Arrival. Assumed pieces and pallets enter the terminal steadily throughout the day rather than concentrated at peak periods or truck arrival times. Arrival and unloading of trucks was not modeled.

4. Sort Line Capacity. Assumed each piece in the sort line would take up slightly under one foot of the line's length. This was used to determine how many pieces each sort line would hold.

5. Sort Line Dumping Procedure. Assumed a line would not be dropped unless it contained at least a pallet load (defined as 13 pieces), and would drop one pallet load at a time to the workstations. Note: the 13 pieces per pallet assumption used in the simulation differs from the EDDS Economic Analysis (EA), also performed by DLA-DORO, which assumed 11 pieces per pallet. The difference is due to a refinement in the operating procedures of the sorter which was made between the time the EA and the simulation analyses were completed.

6. Line Assignment Error. A 1 percent error rate was assumed for flow to the error line on the sorter.

7. Pieces vs. Pallets. When workload data was generated, it was consolidated by shipping unit. If the unit's volume totaled more than 40 cube, it was assumed to go through the terminal as a pallet; otherwise, it would be treated as pieces.

8. Pallets vs. Triwalls. No distinction was made between building pallets and building triwalls; at the stretch wrap, assumed 50 percent would be triwalls and therefore would not require stretch wrapping.

9. Mechanical Failure. Mechanical failure was not modeled; all equipment was assumed to work properly for the duration of the simulation.

10. Pallet Offloading. Offloading of pallets was not modeled for DDOU and DDRV. At other depots, we assumed pallets were offloaded constantly rather than waiting for arrival of outbound trucks.

B. Data. Before modeling the system, it was necessary to determine the expected workload at each depot - the number of pieces and pallets that would flow into the freight terminal from depot stock, from local vendors, and from other depots for transshipment to a local customer. Data on depot stock was obtained from the Material Release Order (MRO) Master History File that is part of the DLA Integrated Data Bank (DIDB) at DORO. Data from January and February 1989 were used. The data were consolidated by shipping unit; if the shipping unit's volume totaled more than 40 cube, it was assumed to move through the terminal as a pallet; otherwise, it would be treated as pieces. The data were screened by shipping mode to include truckload freight (modes A, B, S, T, N, V, I, K, and 9), and small parcel (modes G and 5) that weighed over 30 pounds. Also, material dropped on weekends/holidays were excluded. All Issue Priority Groups (IPG) were included, since EDDS procedures stipulate that all material handled by the system will automatically be downgraded to Issue Priority Group 3. A frequency table was produced of average pieces/pallets dropped to each customer (identified by Destination Cross Reference (DCR)) per day. A similar process was used for transshipped material, using data on material dropped at other depots for a customer in the geographical area of the depot being modeled.

Once the table of customers was made, the transportation office of the depot was contacted to discuss how the sortation system would be used. Out of this discussion came a list of customers which require a dedicated line on the sorter every day, and a list of those customers which would be considered each day for the remaining lines depending on volume.

The list of customers was used to build a table of numbers of pieces and pallets dropped to each customer each workday. Material for destinations not on this list were aggregated by the appropriate EDDS site, or by sections of the local area. For each destination, the daily number dropped was used as a sample to develop a distribution to match it. For simplicity, a mixture of uniform and triangular distributions was used, since they can mimic a wide variety of patterns. The distributions were selected to match both the pattern and sample average of the data. For example, a given destination may have 10 of its 37 workday drops spread evenly between 0 and 10 pieces, with the rest ranging up to 40 but concentrated near 20. This might be described as coming from a Uniform (0, 10) 27 percent of the time, and Triangular (10, 20, 40) 73 percent of the time.

When results of the DDRV simulation were briefed, a comment was made that January was a low volume month. In response to this observation, data for other time periods were reviewed; it was discovered that volume peaks in March and April were up to 30 percent higher than the volume for January and February. Each depot was then reviewed to see if it could handle a 30 percent increase to normal MRO and transshipment volume. DDRV and DDMT were remodeled (results discussed in section VII); the rest of the depots could clearly handle the increase.

There was no data base available from which to generate the amount of material from vendors. However, data had been published by the EDDS Support Office (EDDSO) on the amount of material from vendors in each depot's area and destined to which depot for storage. This data was used to generate the incoming vendor material.

Data used to calculate service and travel time were obtained from the Depot Operations Support Office (DOSO). Service time included the estimated effect of fatigue, breaks, etc. Table 2 gives a summary of this data.

Table 2

TRAVEL AND SERVICE TIMES

CONVEYOR SPEEDS:	
Package conveyor:	120 ft/min
Pallet conveyor:	50 ft/min
SERVICE TIMES:	
Depalletization:	3 sec per piece + 120 sec if stretch wrapped
Data Collection:	49 sec per piece
Pallet Loading:	32 sec per piece
Error Resolution:	30 sec per piece
Auto Stretch Wrap:	120 sec per pallet
Semi-Auto Stretch Wrap:	180 sec per pallet
Verification:	20 sec per pallet if weighed, 5 sec if not
Offload by Forklift:	136 sec per pallet

C. Modeling. Each freight terminal design was simulated using the SLAM simulation language. There were three steps to the modeling effort. First, a FORTRAN program was developed to generate the number of pieces and pallets to each customer according to the distribution derived from the data. Second, a SLAM network was created to represent the movement and processing of pieces and pallets through the freight terminal. Last, user-defined functions were written in FORTRAN to allow detailed control at certain points in the network. These steps are described in more detail below.

The volume generation program was used by the simulation at the start of each workday to determine the flow of pieces and pallets into the system that day. The distributions developed from the data were sampled for each customer, and the number of pieces to be dropped for each sort line determined. These were summed, and the total used to calculate the interarrival times and proportion to each sort line, which were passed to the SLAM model. The process was repeated for transshipment and vendor pieces, and a similar process used for pallet flow into the system.

The SLAM network was designed to model the movement of pieces and pallets along conveyors and the work done to them at different stages. Points at which conveyors merged were modeled as resources so that contention for these points could be modeled. Queues of items waiting for a process were not limited to a specific size so that the amount of necessary queue space could be determined.

User-defined functions were used primarily to assign each incoming piece to a sort line and each incoming pallet to an outbound destination. To do this, the proportion of pieces going to each sort line, calculated in the volume generation program, was compared to a random number to select the proper line and outbound customer. User functions were also used to determine travel times which were dependent on line assignment.

VII. ANALYSIS

A. DDCO. The simulation was run for 10 days, and generated the workload in Table 3. Problems were seen in three areas. First, the data collection area was overworked. Queues built to about 40 pieces per station. Second, sort workers were only, at most, 77 percent utilized even though there were sufficient pieces in the sort lines to build more pallets. This underutilization was caused by sort workers waiting idle while pieces traveled to them from the sorter. Third, the queue at the semi-automatic stretch wrap built to over 30 pallets.

Table 3

DDCO AVERAGE WORKLOAD

756	Avg pieces dropped from depot stock
224	Avg transshipment pieces arrived
1342	Avg vendor LTL pieces arrived
978	Avg vendor small parcels arrived

3300	Avg total pieces entered the system

The simulation was rerun with three changes. Another data collection station was added, a second waiting area for pieces at each sort workstation was added, and a second semi-automatic stretch wrap machine was added. A comparison of queue and utilization statistics is shown in Table 4.

A third run was made, increasing the flow of pieces 10 percent, to "stress test" the new design. No problems surfaced from the increased volume. Some sort lines were underutilized: 17 of the 60 lines built three or fewer pallets over the ten day simulation.

Table 4

DDCO QUEUE SIZES AND UTILIZATION

	Original Design	With Changes
Data Collection		
Max queue per station	39	4
Max utilization	100%	83%
Sort Workers		
Max utilization	77%	84%
Stretch Wrap		
Max Queue	33	3
Max utilization	100%	55%

B. DDMP

A 10-day simulation run generated the average daily workload listed in Table 5. These totals include 450 average pieces/day for the DDMP Container Consolidation Point (CCP), which do not enter the sorter, 525 for MEDALOC, and 75 for DoD Dependent Schools (DODDS). Problems were seen at the data collection workstations, the MEDALOC workstations, and at the sorter workstations.

Table 5

DDMP AVERAGE WORKLOAD

2848	Avg pieces dropped from depot stock
696	Avg transshipment pieces arrived
2217	Avg vendor LTL pieces arrived
2333	Avg vendor small parcels arrived

8094	Avg total pieces entered the system

An initial expected-value analysis showed that six stations would be insufficient for the expected volume of vendor material. When modeled with seven stations, the workers were above capacity four of the ten days, and at 95-99 percent the other six days. Eight data collection stations could handle both normal volume and a 10 percent increase, although they are close to capacity under the higher volume.

The MEDALOC workstation requires four workstations to handle the normal expected workload. However, the data showed occasional spikes of three to five times the normal volume which occurred every two to three weeks. Given that a separate work-around procedure would be used for these spikes, four stations could handle both the normal volume and a 10 percent increase.

At the sorter, again the workers had significant idle time waiting for pieces to travel to them from the sort lines. The design was changed to add a second waiting area at each station, and the simulation rerun. Under normal volume, the sort workers averaged 93 percent utilization, 99 percent maximum for any day. There was minor queing, 14 maximum, at the merge point entering the sorter. A 10 percent increase in volume pushed the sort workers beyond their capacity - 100 percent utilization from day two on. The sort lines filled, and the number of pieces looping to reenter the sorter caused a large queue at the reentry merge point, as shown in Figure 3. (Only eight days were shown because the program exceeded file space constraints and terminated). Adding two palletization stations could cope with the increased volume; no more than 15 pieces were ever waiting to enter the sorter. A comparison of statistics is shown in Table 6.

Table 6

DDMP QUEUE SIZES AND UTILIZATION

	Version 1	Version 2	Version 3
Data Collection			
Avg utilization	87%	95%	95%
Max queue per station	5	22	22
MEDALOC Workstation			
Avg Utilization	85%	91%	91%
Sort Workers			
Avg utilization	93%	100%	82%

Version 1: 8 data collection stations, 4 MEDALOC stations, 8 sort workers.
Version 2: As above, high volume (+ 10%).
Version 3: As above, high volume, 10 sort workers.

C. DDMT. The simulation generated the workload shown in Table 7 when averaged over ten days. For this depot, simulation runs were made for four scenarios: using normal volume and increased volume, each with and without the optional package delivery system. This system takes pieces off the sorter that are destined for those local customers who do not have an assigned line on the sorter. Problems were seen at the data collection workstations and at the sorter.

Table 7

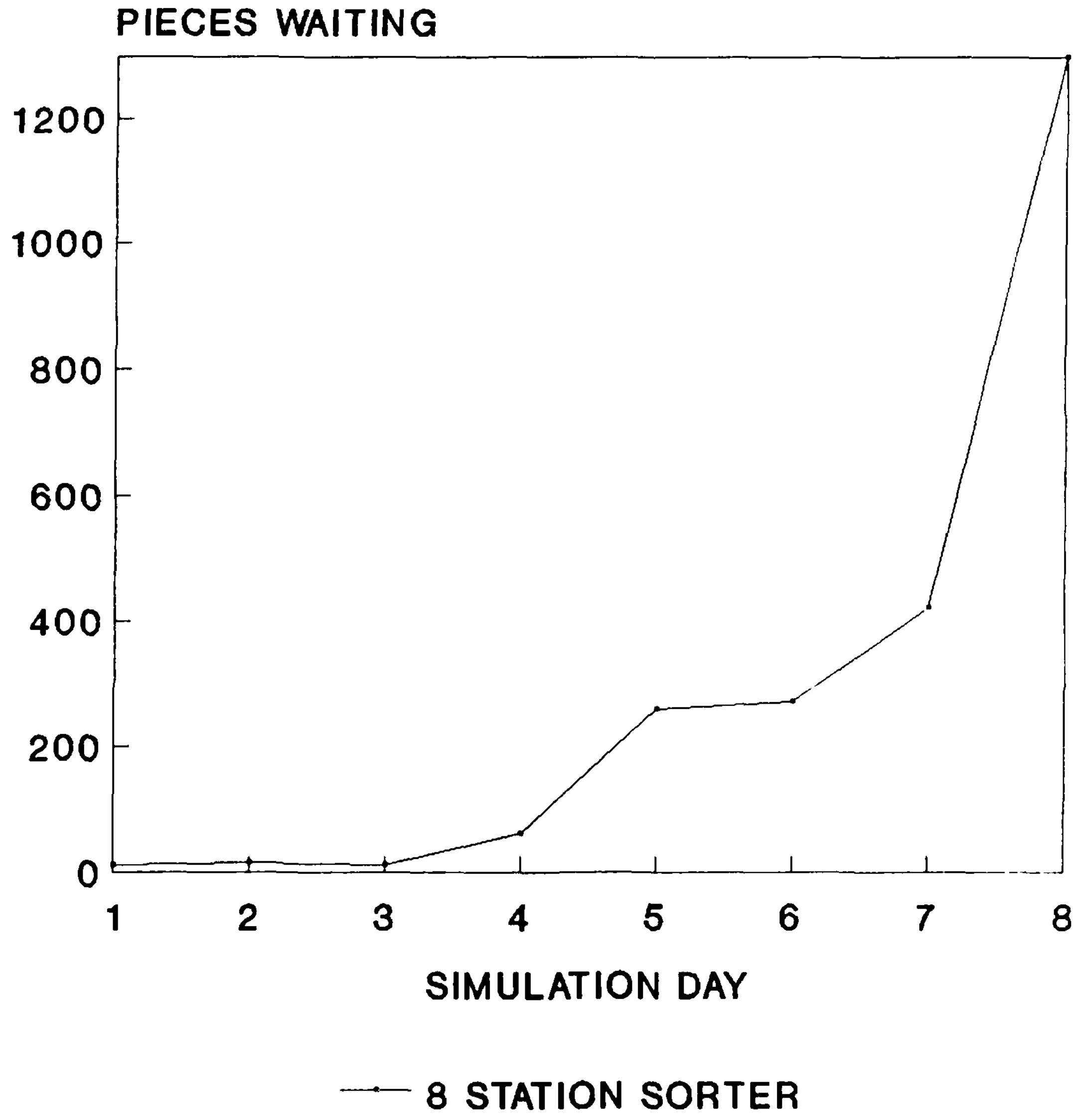
DDMT AVERAGE WORKLOAD

2625	Avg pieces dropped from depot stock
665	Avg transshipment pieces arrived
2750	Avg vendor pieces arrived

6040	Avg total pieces entered the system

Initial expected-value analysis showed four data collection stations would be insufficient for the expected number of vendor pieces. Five stations would barely suffice for the average expected workload, while six could handle up to a 25 percent increase.

Figure 3
QUEUE TO REENTER SORTER
DDMP - HIGH VOLUME



At the sorter, the maximum queue size to reenter varied from zero under normal volume with the package delivery system to 375 under high volume without the system. Under all scenarios, there were large differences in utilization of the sort workers on the same day. This was due to the sorter's design. Under the original design, each palletization station "owned" seven or eight lines. A station could draw from only those lines, and those lines could go to only that station. Therefore, as the workload to different lines varied from day to day, one station could be overworked while the one beside it could be mostly idle.

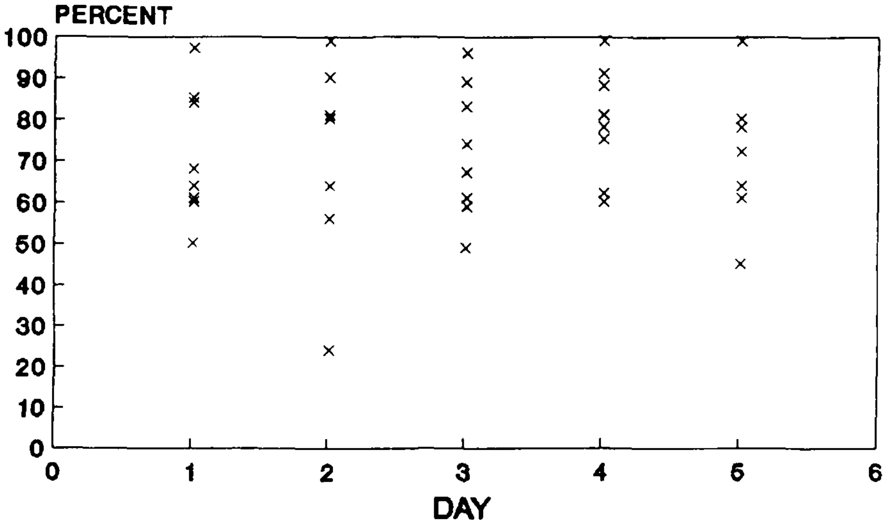
To attempt to correct the uneven utilization, a more flexible sorter design was modeled. The new design was patterned after that used at several other depots, where half the stations draw from lines on each half of the sorter. The chart at Figure 4 shows, for one scenario, how this design evens out the utilization (each "x" represents a worker utilization). Similar results were found using the other three scenarios. Also, no pieces needed to reenter due to a full line in any of the simulations of the new design.

After the results of this analysis were briefed, a follow-on analysis was requested to evaluate three new alternative sorter designs. The first design ('A') added a "feed conveyor" around the perimeter of the sorter which would carry pieces from the sort line to the sort worker who needed it; this design is illustrated in Figure 5. The second design ('B') had a 'U' shaped conveyor, identical to the first design except the top portion of the feed conveyor was removed. The third design ('C') was missing both the top and bottom portions, so there were two separate feed conveyors, one for each side of the sorter.

Rules were required to control the selection of sort line by the sort worker. A "three-zone selection rule" was developed; it is shown graphically in Figure 6. For a given palletization station, the group of seven to eight lines which would reach that station first were the "primary zone" for that station. The group of lines which had to pass one station before reaching this one was the secondary zone; lines needing to pass two stations were the third zone. When a worker finished a pallet, the primary zone was checked, and the fullest line containing at least one pallet load (13 pieces) was dropped. If all primary zone lines had less than 13 pieces, the secondary zone was checked using the same criteria; if all secondary zone lines had less than 13 pieces, the third zone was checked. Only if all lines in all three zones had less than 13 pieces would the worker become idle, rechecking the lines with this procedure every 60 seconds until one drops.

The three designs were simulated using high volume without the package delivery system, since this scenario resulted in the highest workload for the sorter. Significant differences were found between the three designs in the amount of queuing to reenter the sorter, as shown in Figure 7. This resulted from the fact that, in design 'A', all lines could be accessed by three workstations, while in design 'B', there was one group of lines that could be accessed from only one station, and this could still overload that station. In design 'C' there were two stations in this situation. Hence, designs 'B' and 'C' did not fully relieve the inflexibility problem identified in the original analysis.

Figure 4
UTILIZATION OF SORTWORKERS AT DDMT WITH ORIGINAL SORTER



WITH 'FLEXIBLE' SORTER

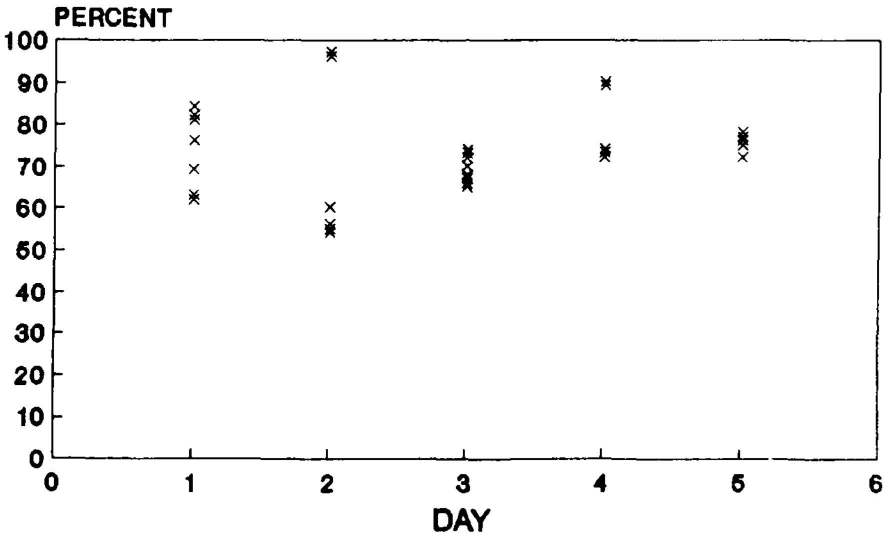


Figure 5

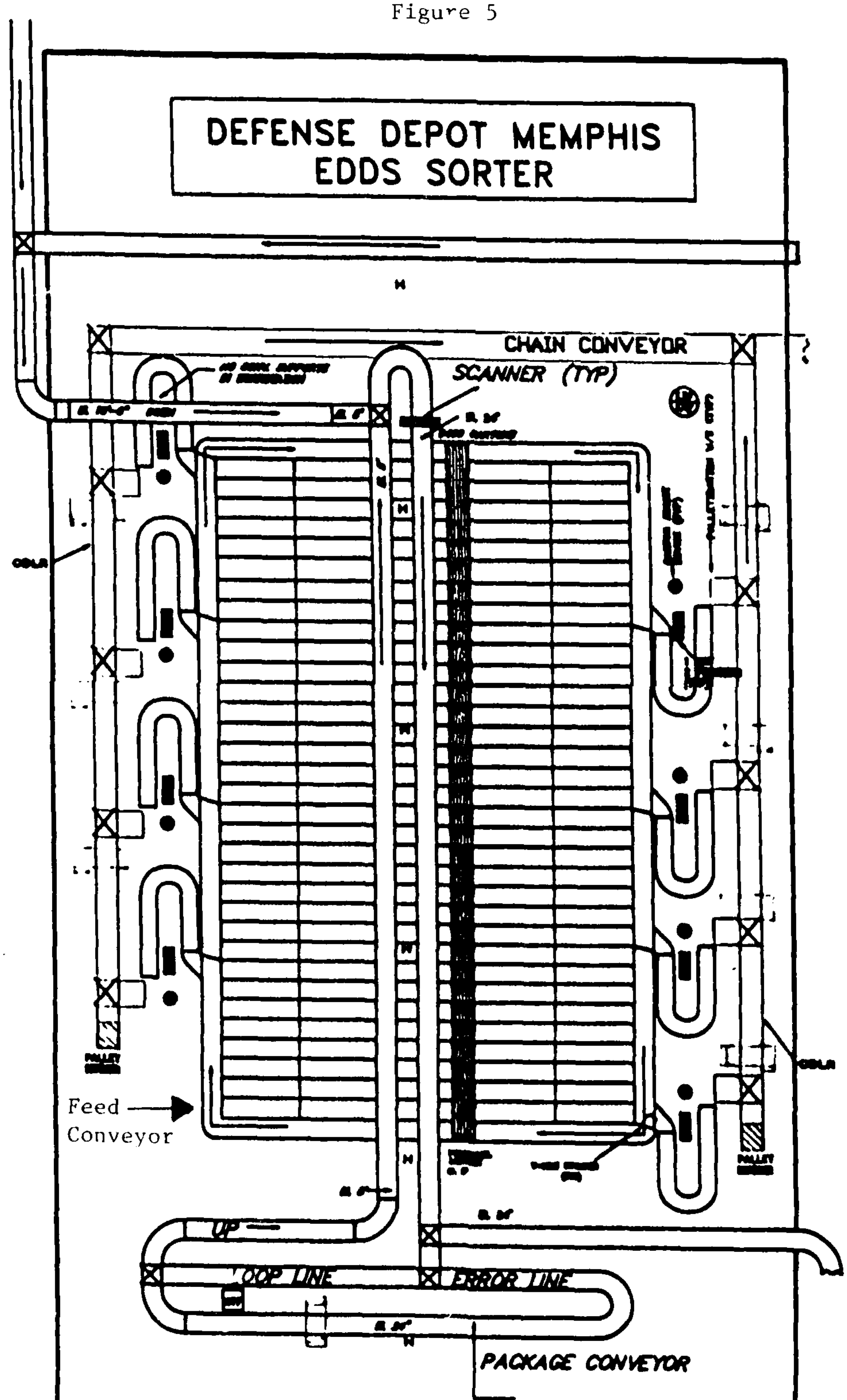

DEFENSE DEPOT MEMPHIS
EDDS SORTER
CHAIN CONVEYOR
SCANNER (TYP)
Feed
Conveyor
UP
LOOP LINE
ERROR LINE
PACKAGE CONVEYOR

Figure 6
THREE – ZONE SELECTION PROCEDURE (DDMT)

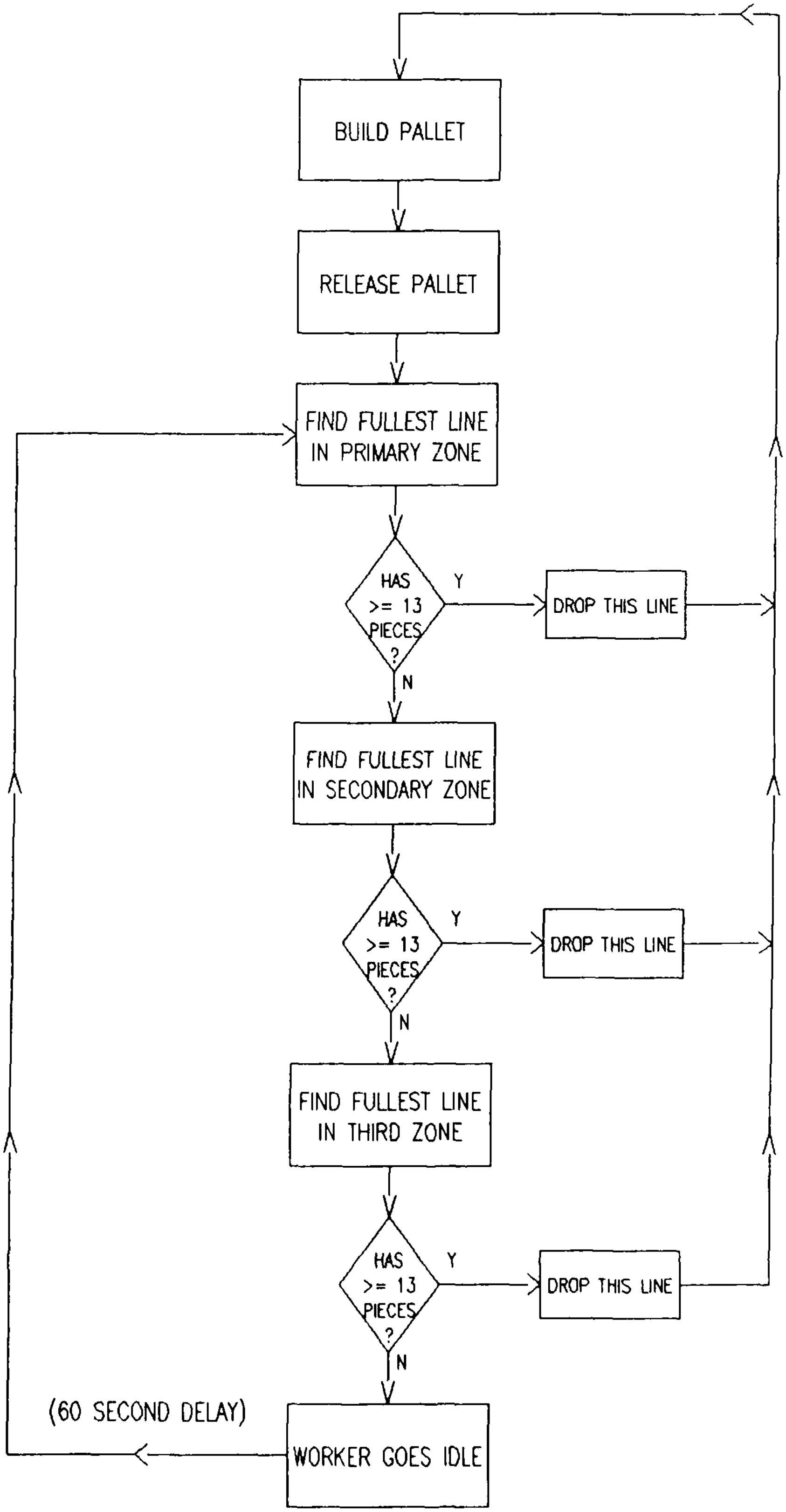
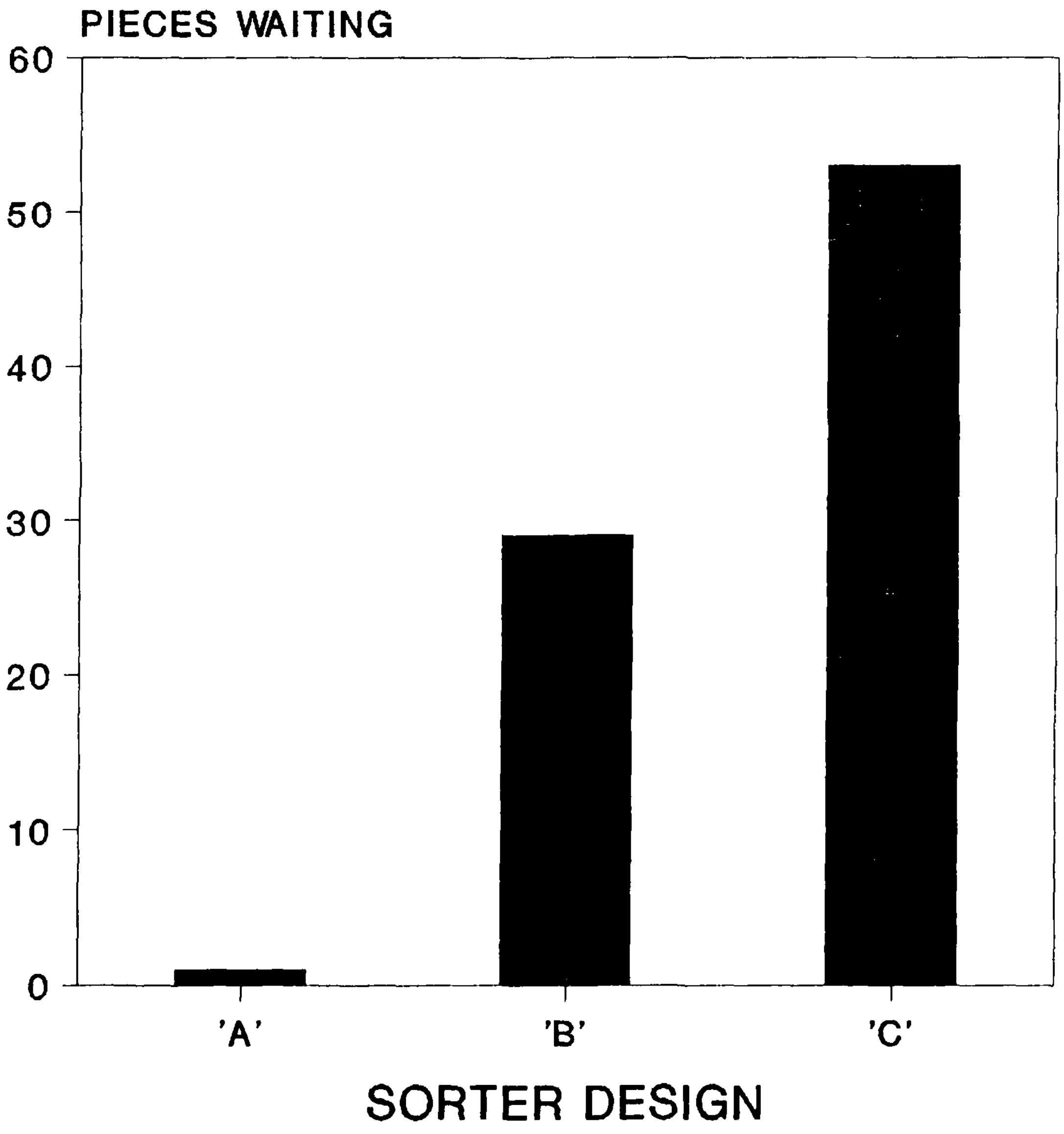


Figure 7
MAX QUEUE TO REENTER SORTER
DDMT NEW SORTER DESIGNS



In response to comments that January may be a low-volume month, the simulation was rerun using a 30 percent increase for depot stock and transshipment volume; vendor volume was left at normal levels. The simulation was run with the package delivery system, since the decision had been made to include it in the design. Problems were found on one day of the simulation when the sorter became overworked. The problem could be alleviated, however, by modifying the line selection procedure so the fullest line in any of the three zones would be dropped, regardless of which zone it was. Therefore, no mechanical design changes were necessary to handle the higher workload.

D. DDOU

Average workload generated over the ten day simulation is shown in Table 8. Of the 2867 depot stock pieces, 1440 were small parcels which normally are not handled by EDDS; they were included in the DDOU workload because, in the Ogden design, they used some of the same package conveyors used by the EDDS system. It was therefore necessary to include the flow of these small parcels to accurately model the merge point on these conveyors. Since these small parcels used their own sortation systems (which are not modeled), they did not affect any other part of the system. Therefore, the average number of pieces entering the EDDS sorter was about 2100, 1440 less than the total pieces generated. No problem areas were seen using the normal workload or a 10 percent increase. Eleven sort lines averaged less than one pallet per day, but they were all lines assigned to EDDS sites or depots and could not be eliminated. Note: At the time of this simulation, the client had agreed to add a second wait area at the palletization station for pieces and empty pallets, so this change was included in the original model.

Table 8

DDOU AVERAGE WORKLOAD

2867	Avg pieces dropped from depot stock
617	Avg transshipment pieces arrived
61	Avg vendor pieces arrived

3545	Avg total pieces entered the system

E. DDRV

Table 9 shows the average daily workload over the ten day simulation. Using this volume, no problems developed. Under a 10 percent increase, however, problems were seen at data collection and sort workstations. Note: At the time of this simulation, the client had agreed to add a second wait area at the palletization station for pieces and empty pallets, so this change was included in the original model.

Table 9

DDRV AVERAGE WORKLOAD

2103	Avg pieces dropped from depot stock
783	Avg transshipment pieces arrived
1017	Avg vendor LTL pieces arrived
1136	Avg vendor small parcels arrived

5039	Avg total pieces entered the system

Four data collection stations proved insufficient to handle a 10 percent increase in expected volume. Workers were at or near 100 percent utilization throughout the simulation, and up to 82 pieces maximum were waiting at a station. Adding a fifth data collection station reduced utilization to 81 percent and the maximum queue size to four.

Although the sort lines never got full enough to cause looping, the workers were at or near capacity, averaging 95 percent utilization under the 10 percent volume increase. Adding a seventh sort worker would reduce this to 81 percent. These statistics are summarized in Table 10.

In response to observations that January was often a low-volume month, the simulation was rerun increasing depot stock and transshipment volume 30 percent; vendor remained at normal levels. This was to reflect expected volumes during the peak months of March and April. The simulation showed that the system, with the changes already recommended, could handle the higher volume.

Table 10

DDRV QUEUE SIZES AND UTILIZATION
(High Volume)

	Original Design	With Changes
Data Collection		
Max queue per station	82	4
Avg utilization	100%	81%
Sort Workers		
Avg utilization	95%	81%

F. DDTC

Average workload over the ten day simulation is shown in Table 11. On the initial simulation run, sort workers could not keep up with the workload because of the idle time waiting for pieces and empty pallets. When a second waiting area was added at each palletization station, the sort workers could keep up with the normal volume.

Table 11

DDTC AVERAGE WORKLOAD

2567	Avg pieces dropped from depot stock
378	Avg transshipment pieces arrived
418	Avg vendor pieces arrived

3363	Avg total pieces entered the system

When the model was run at normal volume with this initial change made, problems were seen at the MEDALOC workstation and stretch wrap machine. One MEDALOC workstation could not handle the expected volume; average utilization was 100 percent. Adding a second station reduced utilization per station to 55 percent for normal volume, 60 percent for high volume. The stretch wrap could handle the workload; the two stations were utilized 55 percent average, 75 percent maximum each. However, the queue occasionally built to two or three pallets, which blocked the last palletization station.

When the expected volume was increased 10 percent, four sort workers could no longer keep up with the workload; utilizations were 100 percent and the queue to reenter the sorter built to over 300 pieces. Increasing the number of palletization stations to six reduced average utilization to 60 percent, maximum utilization to 91 percent. These statistics are summarized in Table 12.

Table 12

DDTC QUEUE SIZES AND UTILIZATION
(High Volume)

	Original Design	With Changes
MEDALOC Workstation		
Avg utilization	100%	60%
Sorter		
Max queue to reenter	300+	0
Avg utilization	100%	60%

APPENDIX A

EDDS Freight Terminals
Mechanization Designs

Figure A-1

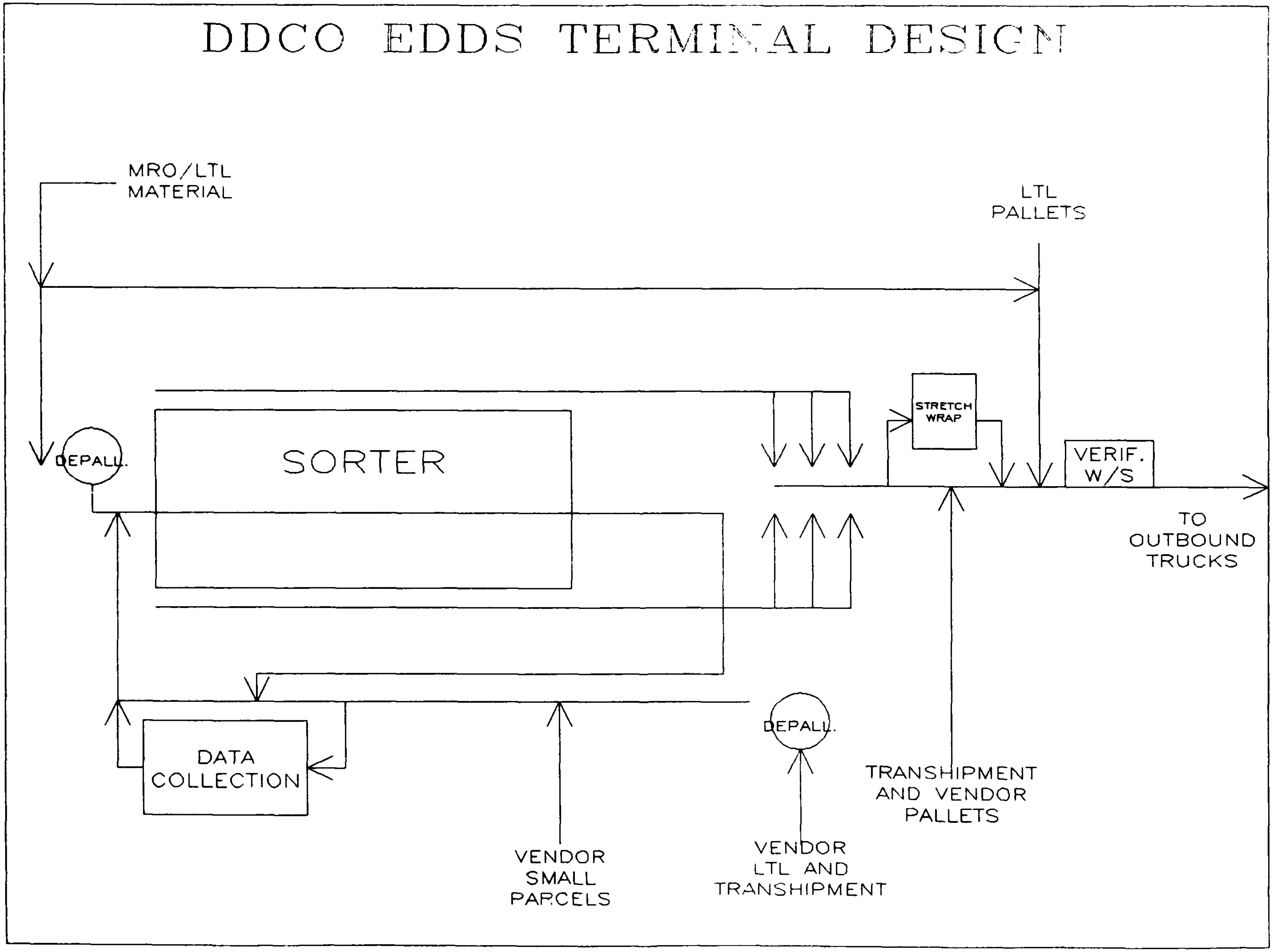
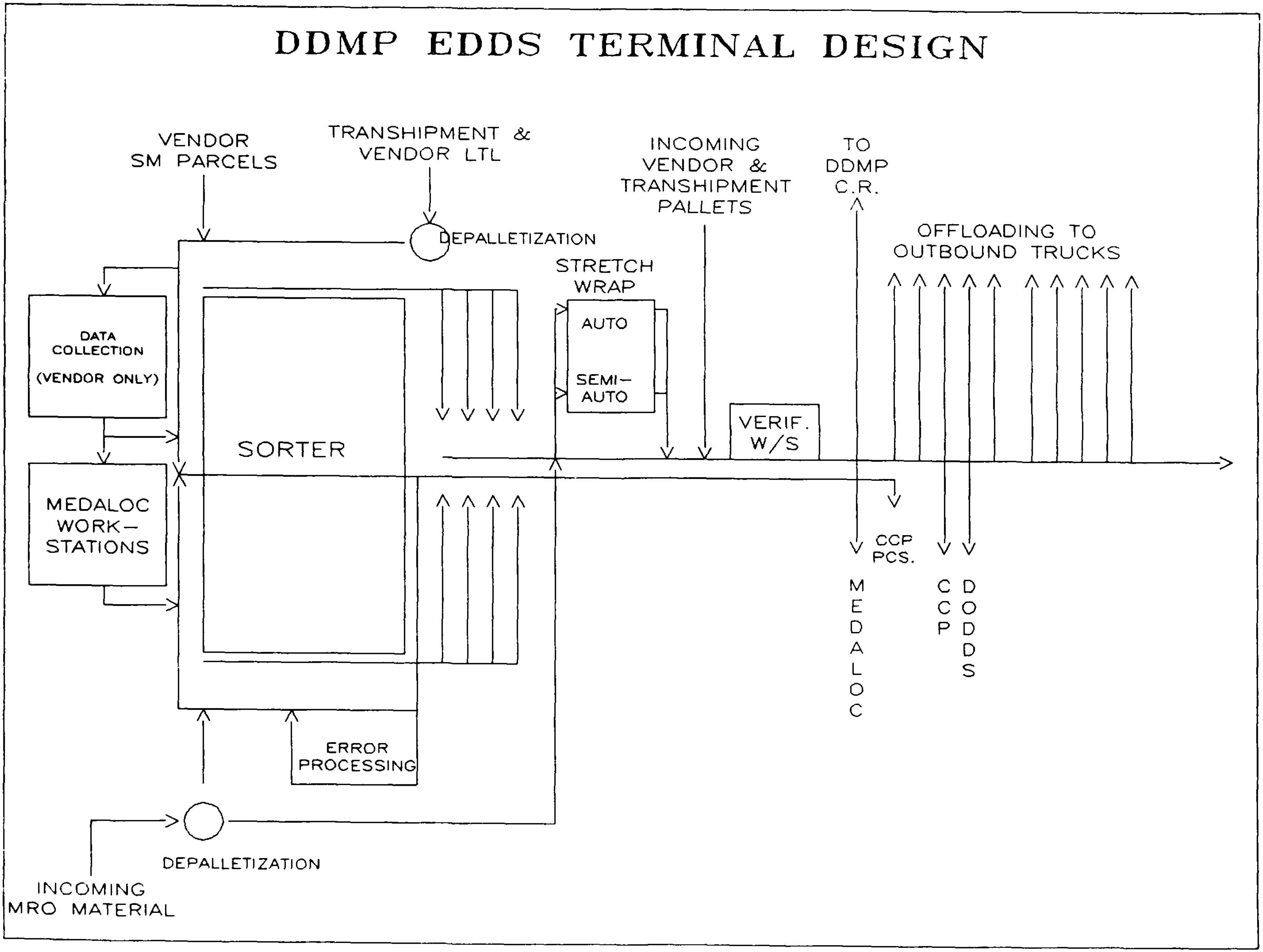

DDCO EDDS TERMINAL DESIGN
MRO/LTL MATERIAL
LTL PALLETS
DEPALL.
SORTER
STRETCH WRAP
VERIF. W/S
TO OUTBOUND TRUCKS
DATA COLLECTION
DEPALL.
TRANSHIPMENT AND VENDOR PALLETS
VENDOR SMALL PARCELS
VENDOR LTL AND TRANSHIPMENT

Figure A-2



DDMP EDDS TERMINAL DESIGN
VENDOR SM PARCELS
TRANSHIPMENT & VENDOR LTL
DEPALLETIZATION
INCOMING VENDOR & TRANSHIPMENT PALLETS
TO DDMP C.R.
OFFLOADING TO OUTBOUND TRUCKS
STRETCH WRAP
AUTO
SEMI-AUTO
DATA COLLECTION (VENDOR ONLY)
SORTER
VERIF. W/S
MEDALOC WORK-STATIONS
CCP PCS.
MEDALOC
CCP
DODDS
ERROR PROCESSING
DEPALLETIZATION
INCOMING MRO MATERIAL

Figure A-3

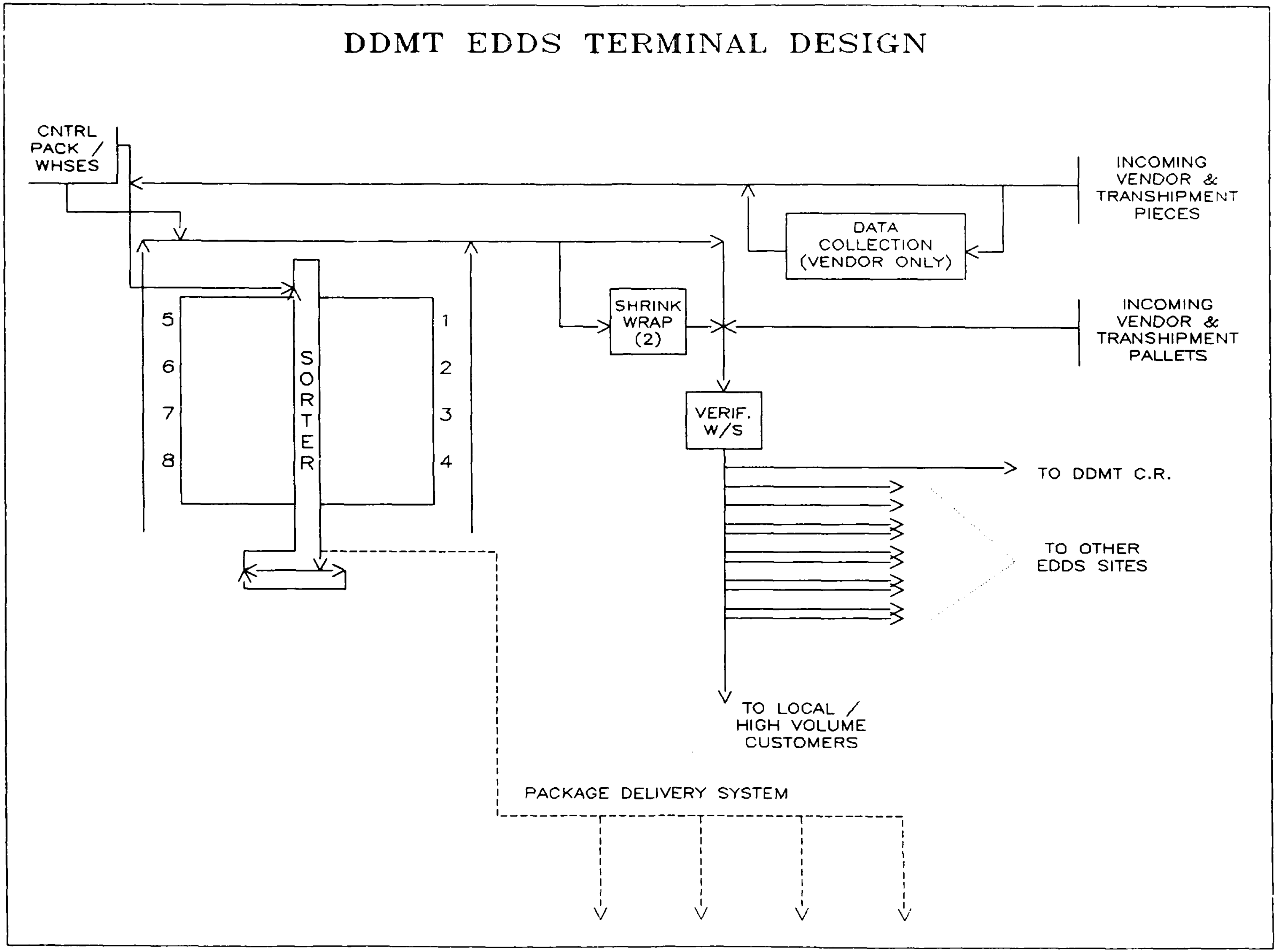

DDMT EDDS TERMINAL DESIGN
CNTRL PACK / WHSES
INCOMING VENDOR & TRANSHIPMENT PIECES
DATA COLLECTION (VENDOR ONLY)
INCOMING VENDOR & TRANSHIPMENT PALLETS
SHRINK WRAP (2)
VERIF. W/S
SORTER
1
2
3
4
5
6
7
8
TO DDMT C.R.
TO OTHER EDDS SITES
TO LOCAL / HIGH VOLUME CUSTOMERS
PACKAGE DELIVERY SYSTEM

Figure A-4

DDOU EDDS TERMINAL DESIGN

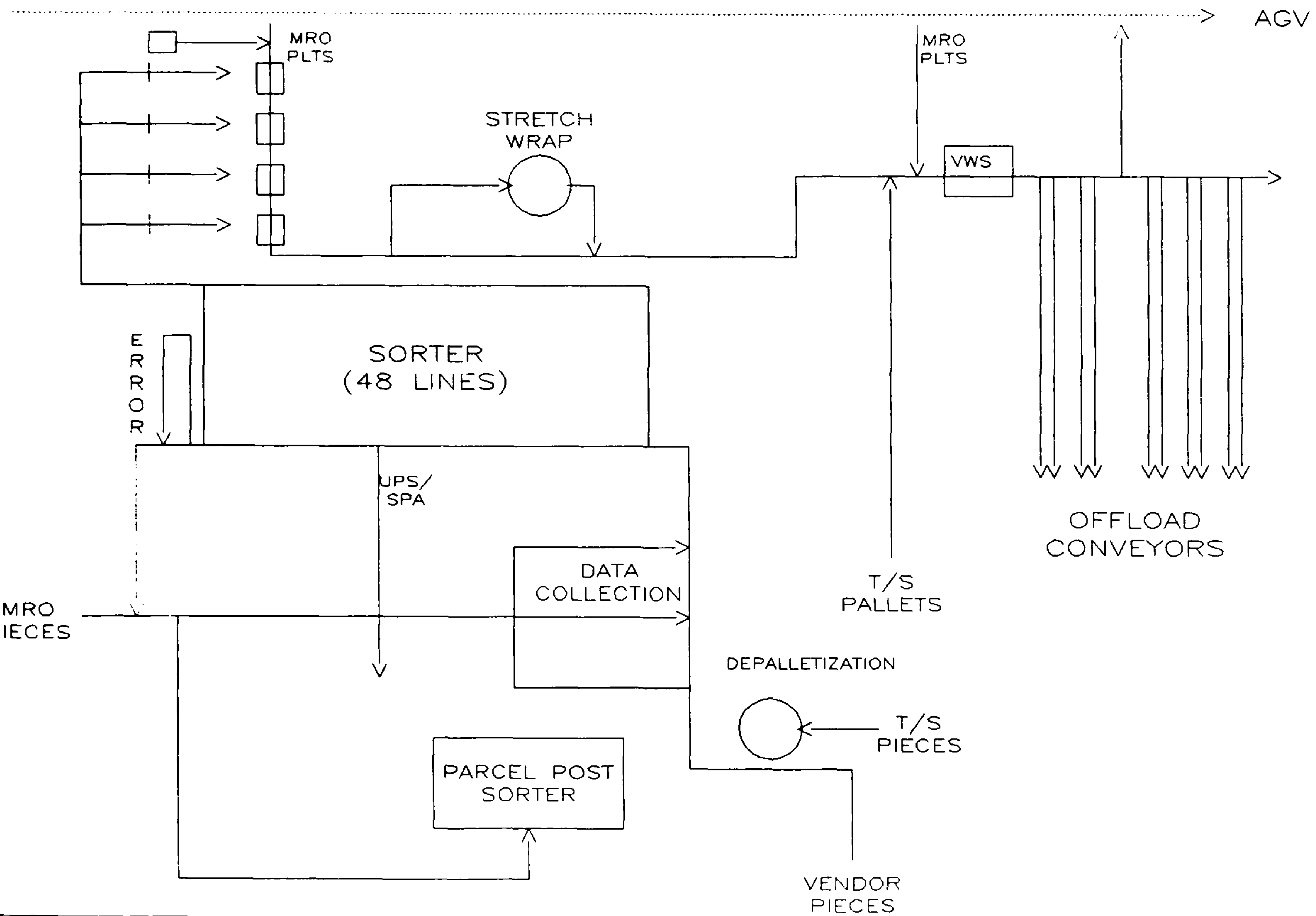


Figure A-5

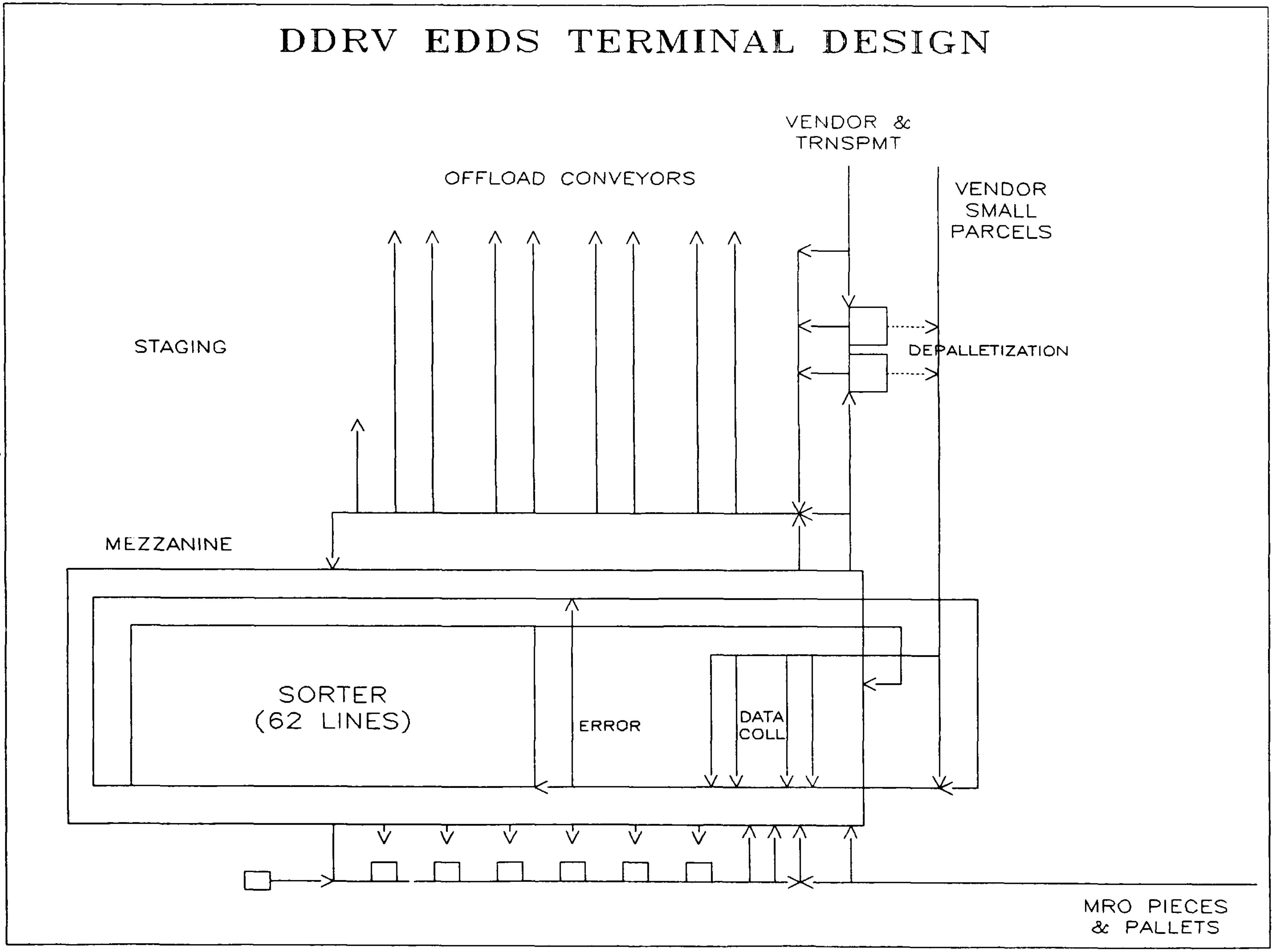

DDRV EDDS TERMINAL DESIGN
VENDOR &
TRNSPMT
OFFLOAD CONVEYORS
VENDOR
SMALL
PARCELS
STAGING
DEPALLETIZATION
MEZZANINE
SORTER
(62 LINES)
ERROR
DATA
COLL
MRO PIECES
& PALLETS

Figure A-6

DDRV EDDS TERMINAL DESIGN
(WITHOUT MEZZANINE)

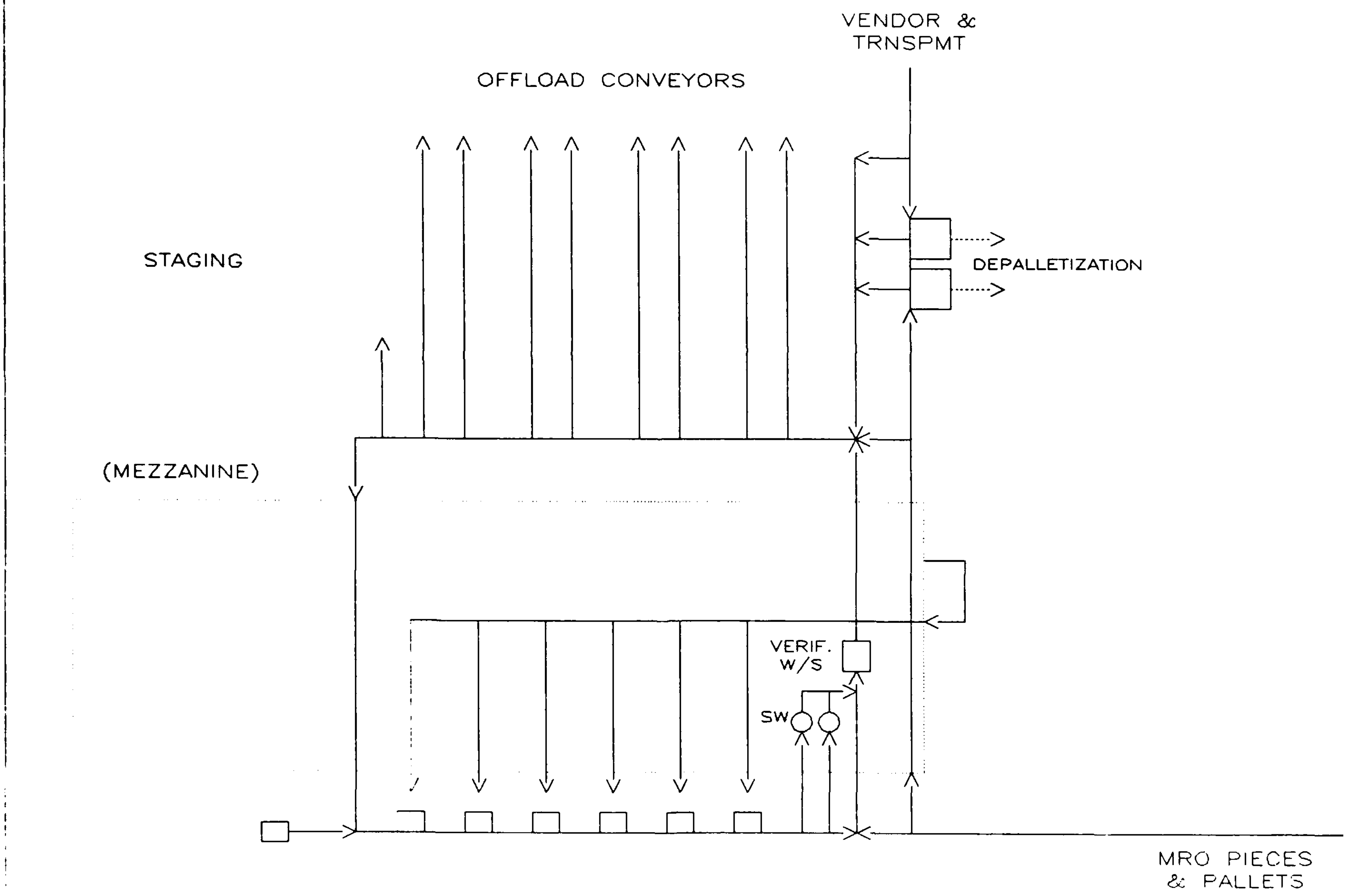
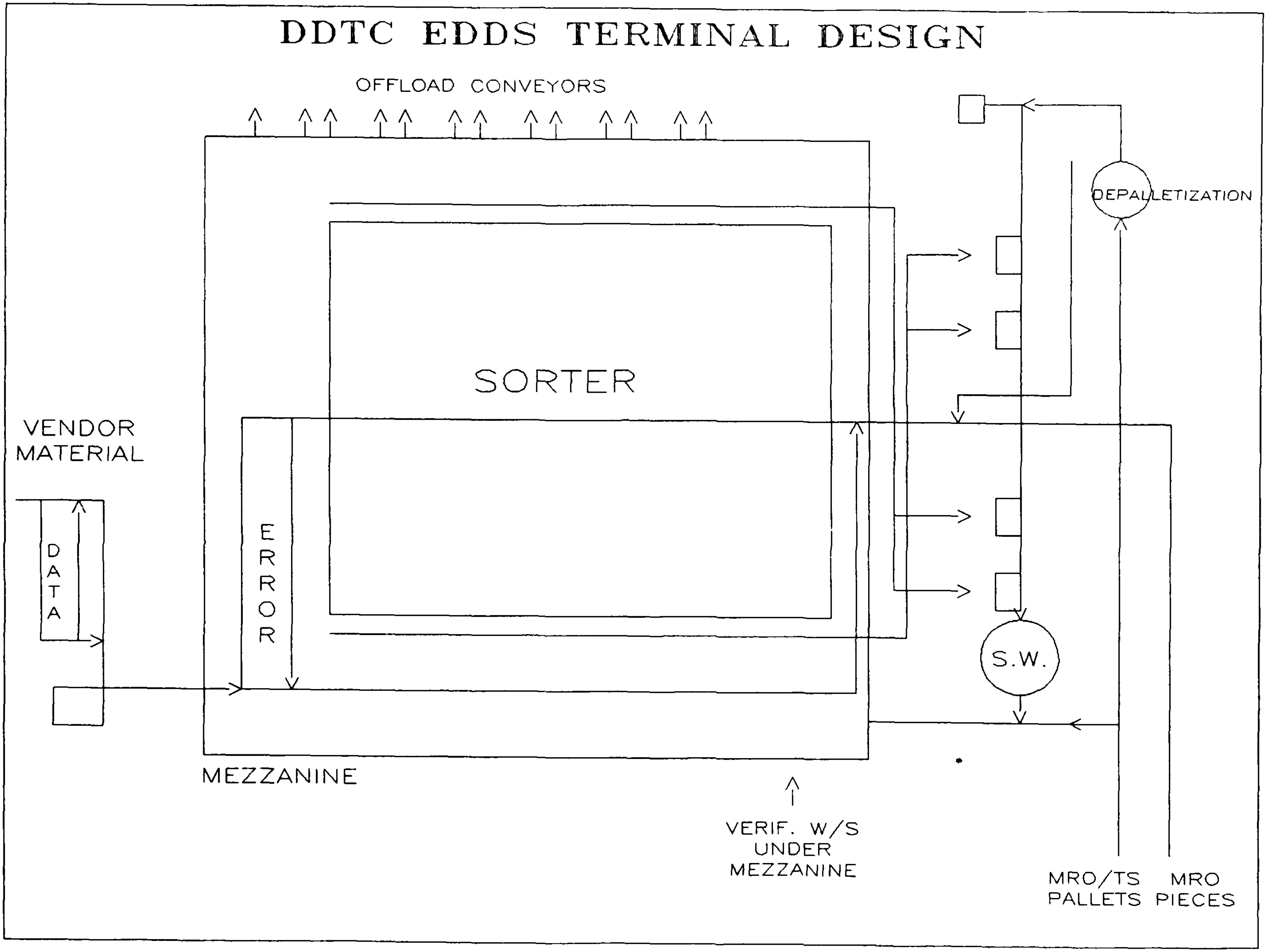


Figure A-7


DDTC EDDS TERMINAL DESIGN
OFFLOAD CONVEYORS
SORTER
VENDOR MATERIAL
DATA
ERROR
MEZZANINE
VERIF. W/S UNDER MEZZANINE
DEPALLETIZATION
S.W.
MRO/TS PALLETS
MRO PIECES

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13. ABSTRACT *(Maximum 200 words)*
This report presents the results of simulation analyses of proposed mechanization design of the freight terminals at each of the six Defense Logistics Agency (DLA) depots. The mechanization project is part of the Enhanced DLA Distribution System (EDDS), with designs developed by the DLA Depot Operations Support Office (DLA-DOSO). The purpose of the simulation analyses is to identify any problems or possible improvements and recommended changes. The analyses indicated that the efficiency of sort workers could be improved at all depots by adding another queue area for arriving pieces and empty pallets. Also, additional workstations were required at several depots for data collection, Medical Air Line of Communication (MEDLOC) processing, and palletization. Defense Depot Columbus, Ohio, required additional stretch wrap capability, while Defense Depot Memphis, Tennessee, needed an entirely new sorter design to improve efficiency. Additionally, we found that sortlines and pallet conveyor lines could be shortened at four depots, reducing total costs by almost $500,000.

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